THESIS

UNDERSTANDING RANCHER PERSPECTIVES ON NONLETHAL LIVESTOCK PROTECTION APPROACHES

Submitted by

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ABSTRACT

UNDERSTANDING RANCHER PERSPECTIVES ON
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As human and carnivore populations grow, livestock and carnivores are forced to share shrinking habitat, resulting in predation events which can negatively impact both livestock producers and wildlife. Reducing human-carnivore conflict requires solutions to mitigate predation events, including various nonlethal livestock protection approaches such as fencing and livestock guardian dogs. While some research has studied approaches' effectiveness, little is known about how producers feel about their current livestock protection options. In this study, we explored Colorado ranchers' perspectives about livestock protection tools and strategies through 26 in-depth semi-structured interviews. When describing livestock protection approaches, ranchers discussed approaches they were aware of and familiar with, their primary motivations for using approaches, and barriers they face when considering implementing these approaches. Ranchers described primary motivations as successful experiences, others' positive stories, concern about carnivores, and other perceived benefits to their operations. Ranchers described barriers to implementing these approaches as negative personal experiences, others' negative stories, peer pressure, perceived ineffectiveness and/or incompatibility of the approaches, lack of knowledge/expertise and resources, tolerance of carnivores, and opposition to change. Additionally, ranchers described numerous non-predation related environmental and sociopolitical challenges their ranching operations face, which may limit their capacity to learn and implement new approaches. These findings can help practitioners collaborate with livestock

producers, develop relevant materials that address producers' interests and needs, and encourage rancher adoption of nonlethal livestock protection approaches. Understanding ranchers' motivations and barriers to using livestock protection approaches is essential to finding culturally relevant pathways to protect both livestock and wild carnivores.

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DEDICATION

This work is dedicated to my loved ones who did not live to see me start graduate school but whose presence I have felt beside me every step of the way. To my incredible dad, Steven J. Brager, a nature-lover who believed in me, encouraged me to follow my dreams, and made me laugh more than anyone. To my grandparents, Herman and Betty Brager, whose steadfast support made my education possible and whose warmth always made me feel at home. To my soul cat, Señor, my constant companion through every joy and challenge, thank you for growing up with me. Finally, to all the animals and people who have suffered and lost lives due to human-wildlife conflict, I dedicate my work to you and to the hope of a more peaceful and compassionate future for all beings.

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Introduction

Carnivore conflict with livestock production is a major source of human-carnivore conflict worldwide, impacting people, livestock, and carnivores (Davoli et al., 2022; Klees van Bommel et al., 2020). Animal agriculture currently occupies more than 30% of the land on earth, and as livestock production continues expanding to meet the demands of a growing human population, carnivores and livestock are increasingly forced to share shrinking habitat, coming into conflict with each other more frequently (Ripple et al., 2014). These carnivore-livestock interactions are a key driver of carnivore species decline, impacting 88% of large carnivores worldwide. Given this sharp decline and increasing conflict (Ripple et al., 2014), finding lasting ways for both livestock and carnivores to coexist in shared landscapes is vital (Steinfeld et al., 2006).

Carnivores can pose both direct and indirect threats to livestock, which is costly to producers and can threaten ranching livelihoods (Howery & DeLiberto, 2004). Direct effects include killing and injuring livestock, whereas indirect effects on livestock include increased vigilance behavior, reduced foraging efficiency, reduced conception and weaning weights, and increased vulnerability to illness (Ramler et al., 2014; Steele et al., 2013). While there are compensation programs to reimburse ranchers for direct losses to carnivores, indirect losses are more difficult to measure, poorly understood, and thus are typically not compensated (Ramler et al., 2014). These negative impacts on ranching operations increase the likelihood that ranchers kill carnivores in retaliation, which further imperils carnivore species and may not serve in protecting livestock (Creel & Rotella, 2010; van Eeden, Crowther, et al., 2018).

Lethally removing carnivores, either by hunting a population to reduce overall numbers or killing targeted individuals presumed to have predated on livestock, is one of the most common carnivore-livestock conflict reduction approaches (van Eeden, Crowther, et al., 2018). Despite historical reliance on lethal removal, it has several shortcomings, including that it is not necessarily an effective strategy for reducing further predation, does not address underlying livestock vulnerability, may even increase predation issues (Conner et al., 1998; Macon, 2020; Peebles et al., 2013), and it is falling out of public favor (Slagle et al., 2017). Hunting populations as a lethal removal method is not necessarily effective for protecting livestock because indiscriminately removing carnivores does not target the offending individuals (Conner et al., 1998). In fact, lethal removal can increase livestock predation by disrupting carnivore social structure, temporarily shifting demographics to younger, bolder individuals (Peebles et al., 2013). Lethal removal can have unintended negative consequences, indicating a need for alternative methods that are more effective at reducing predation. Further, public attitudes are increasingly finding lethal methods of managing carnivores to be inhumane (Slagle et al., 2017).

Shifting away from lethal removal means we must better understand how to help ranchers adopt nonlethal approaches to protecting their livestock, and, by extension, carnivores. There are various nonlethal alternatives to reducing carnivore-livestock conflicts, which we refer to as livestock protection approaches or approaches. Two main categories of approaches are available to ranchers: tools and strategies. Tools tend to be physical devices (e.g., fladry, fencing, scare devices, livestock guardian animals) that focus on managing carnivores by frightening them or physically preventing them from accessing livestock. Strategies are practices integrated into ranch management, such as stockmanship (low stress livestock handling), calving management, and range riding (staying near livestock to monitor them and carnivores), etc. (Bruns et al., 2020;

Parks & Messmer, 2016). Strategies tend to focus on husbandry and managing livestock, rather than managing carnivores, making livestock less vulnerable to predation (Shivik, 2004). While there are many approaches to choose from, there is a gap in our understanding of factors that influence when producers choose to utilize them (Coppock & Birkenfeld, 1999).

To address this gap, we applied a community-based social marketing (CBSM) framework, which integrates psychological knowledge from the social sciences and social marketing to encourage community level behavior change (McKenzie-Mohr, 2011). CBSM is a practical behavior change framework that has been widely employed for encouraging conservation behaviors and has been suggested for promoting wildlife-friendly practices in agricultural contexts (Willcox et al., 2012). CBSM highlights the importance of identifying barriers to adoption of a new behavior and selecting an appropriate strategy to remove barriers while leveraging benefits (McKenzie-Mohr & Schultz, 2014). Where more traditional behavior change campaigns focused on delivering information tend to be ineffective at changing behaviors (Baruch-Mordo et al., 2011), CBSM offers a proven alternative approach to designing effective interventions by using identified motivations and barriers to select appropriate behavior change tools (McKenzie-Mohr, 2011) tailored, in this case, to encouraging rancher adoption of livestock protection approaches.

CBSM also expands on Theory of Planned Behavior, which posits that human behavior is driven by values, attitudes, beliefs, and norms (Ajzen, 1991). Theory of Planned Behavior has been widely applied in human dimensions contexts, including understanding ranchers' behavioral intentions around incorporating wildlife management into their operations (Willcox et al., 2012). Ranchers' beliefs about wildlife, ecosystems, government agencies, livestock protection approaches, and social dynamics are behavioral drivers that influence whether they

adopt particular management strategies (Ferguson & Bargh, 2004). Other key factors driving ranchers' willingness to adopt approaches include attitudes toward wildlife agencies, understanding how to respond to carnivore interactions, and value for ecosystem health that includes predators (Bogezi et al., 2021; Smith et al., 2025). Conversely, negative attitudes toward regulations and compensation programs, distrust of government, skepticism about approach effectiveness, social divides, and financial pressures can deter adoption (Bogezi et al., 2021; Smith et al., 2025; Symmes, 2022). Both CBSM and Theory of Planned Behavior highlight the powerful behavioral influence of social norms, with Theory of Planned Behavior suggesting that people behave in ways they believe others expect them to (McKenzie-Mohr & Schultz, 2014; Ajzen, 1991). Complex social factors, including deeply rooted cultural views, individual attitudes, and perceptions of social norms, strongly influence the dynamics of human-wildlife conflict, suggesting that addressing conflicts requires a broader interdisciplinary approach to achieve lasting solutions (Dickman, 2010). Hence, we turned to CBSM, which incorporates social psychology, social sciences, and social marketing, to investigate factors influencing ranchers' management decisions and to inform interventions that could encourage adoption of livestock protection approaches (McKenzie-Mohr & Schultz, 2014; Stewart, 2014).

The CBSM framework we applied outlines five steps to facilitate behavior change: 1) identify the desired behavior, 2) identify barriers and motivations to adoption, 3) design a strategy to overcome barriers and leverage motivations, 4) pilot the strategy, and 5) implement on a larger scale and evaluate impacts (McKenzie-Mohr & Schultz, 2014). At its core, CBSM focuses on reducing barriers and enhancing motivations to support a target group in adopting a new behavior (McKenzie-Mohr, 2011), which is why we focused on the second step - identifying motivations and barriers that ranchers face when employing livestock protection approaches. Our

study aimed to explore ranchers' familiarity with various livestock protection approaches and factors influencing their willingness to adopt approaches in the context of livestock-carnivore conflict in Colorado, USA. Carnivore-livestock conflicts resulting in death, injury, and disappearance of livestock contribute to ongoing lethal removal of carnivores from Colorado's landscape (United States Department of Agriculture, 2024). Our specific objectives were to understand which nonlethal livestock protection approaches Colorado ranchers are aware of and/or familiar with, what motivates ranchers to implement these approaches, what barriers ranchers face when considering implementing these approaches, and what challenges ranchers face in their operations more broadly.

Methods

Study Site

Colorado livestock operations include about 2.8 million cattle (*Bos taurus*) and 415,000 sheep (*Ovis aries*) annually (United States Department of Agriculture, 2017). About 65% of Colorado's land base consists of rangelands (Hannebaum, 2018) that also serve as shared habitat for significant coyote (*Canis latrans*), mountain lion (*Puma concolor*), and black bear (*Ursus americanus*) populations, each of which may pose a threat to livestock. Our study is particularly timely because it coincides with the state's voter-mandated gray wolf (*Canis lupus*) reintroduction, which passed in 2020. Ten wolves were reintroduced to Colorado in December 2023, when we initiated our rancher interviews, followed by an additional 15 wolves reintroduced in January 2025. While wolf reintroduction has elevated the conversation about nonlethal livestock protection approaches in Colorado, these same principles apply to other carnivores as well.

Approach

The first author conducted semi-structured interviews to gather ranchers' lived experience with and perspectives on livestock protection approaches for ranching in Colorado's carnivore-rich landscape. Before the interviews, we preselected the topics and questions to be discussed. However, given the semi-structured nature of the interviews, the phrasing and sequence of questions varied during each interview, depending on the interviewee's responses (Creswell & Creswell, 2017). The exploratory nature of this qualitative research helped uncover meaningful beliefs behind ranchers' perspectives (Small & Calarco, 2022).

Recruitment and Sample

Between October 2023 and August 2024, we recruited rancher interview participants by reaching out to local organizations (i.e., government, nonprofit, and academic) that have regular engagement with livestock producers in the state. Our recruitment partners shared rancher contact information, and we provided potential interviewees with a project summary, explained our interest in understanding their perspectives, described confidentiality and consent procedures, and invited them for an interview (see Appendix A - Project Summary). We obtained informed consent twice: first, when we recruited participants, by either attaching the consent form to the invitation email or by verbally explaining it on the phone, and second, immediately before the interview we gave them the printed consent form or verbally explained it again (see Appendix B - Consent). Colorado State University's Institutional Review Board approved all study procedures (protocol #4914).

Between November 2023 and September 2024, we interviewed 26 Colorado ranchers who grazed livestock in the following counties: Archuleta (n=1), Bent (n=1), Cheyenne (n=1), Delta (n=1), Eagle (n=1), Gunnison (n=2), Jackson (n=3), Kit Carson (n=1), La Plata (n=2),

Larimer (n=1), Lincoln (n=1), Mesa (n=1), Moffat (n=2), Montezuma (n=4), Montrose (n=1), Otero (n=2), Pitkin (n=1), Pueblo (n=1), Routt (n=4), Saguache (n=1), Washington (n=1), and Yampa (n=1) (Table 1). Interviewees had cattle and/or sheep operations of various sizes and grazed on both private and public lands. Twenty-one interviews were with a singular participant, four interviews were with two family members, and one interview was with a team of ranch colleagues. Interviewees self-reported as individual ranchers, ranching couples, ranching families, teams of ranch staff, and, in one case, ranching for tribal government. Interviews ranged in duration from 50 to 180 minutes.

Table 1: Number of rancher interviewees per Colorado county.

County	***n***
Archuleta	1
Bent	1
Cheyenne	1
Delta	1
Eagle	1
Gunnison	2
Jackson	3
Kit Carson	1
La Plata	2
Larimer	1
Lincoln	1
Mesa	1
Moffat	2
Montezuma	4
Montrose	1
Otero	2
Pitkin	1
Pueblo	1
Routt	4
Saguache	1
Washington	1
Yampa	1

Interview Instrument Design and Data Collection

Our interview guide (see Appendix C - Interview Guide) had an arc of questions which facilitated in-depth conversations about ranchers' awareness of and experiences with livestock protection approaches, potential motivations and barriers to incorporating these approaches into their operations, and broader ranching challenges. There were five categories included in our interview guide: 1) questions about personal ranching history, current ranching context, and management practices, 2) questions about concerns and challenges broadly as well as experiences with predation, 3) questions about perceptions of and experiences with livestock protection approaches, 4) questions about where they go to learn about livestock protection approaches and other ranching practices, and 5) questions about what kind of support might be helpful to them and other Colorado ranchers. This arc of questions facilitated a natural flow of conversation, addressing our core research questions in the middle, and ending with thoughts about a supportive path forward.

We conducted interviews in person, online via Zoom, and by phone. We recorded in-person and Zoom interviews using Voice Record Pro (Dayana Networks Ltd., 2024) and phone interviews using Rev Call Recorder (Rev.com, Inc., 2024). We wrote detailed summary notes immediately following each interview. All audio recordings were transcribed using Otter.ai (Otter.ai, 2024) immediately following each interview, at which point they were anonymized. To protect confidentiality, we did not use individual names or other personally identifiable information and kept all notes and recordings in a secure server only accessible to collaborators on this project.

Analysis

We conducted thematic content analysis and two coding cycles. First cycle coding included two steps. In the first step, the first author, a research assistant, and two expert reviewers used summary notes and a subset of four interviews, selected for their breadth of ranchers' responses, to iteratively develop a codebook by inductively identifying patterns, meanings, and themes in ranchers' responses as related to our research questions (Saldana, 2013). In the second step, the first author and the research assistant assigned a succinct description to each identified theme, and these descriptions collectively formed the draft codebook. We coded the same interviews according to the draft codebook, refined the codebook in collaboration with two expert reviewers, and revised codes and their definitions until reaching consensus on code definitions and assignments (Mathison, 1988), thereby achieving a final codebook including eight categories and 85 themes (see Appendix D - Codebook). We used the final codebook to code all interviews in Dedoose (SocioCultural Research Consultants, LLC., Version 9.0.107).

In second cycle coding, the first author and research assistant applied our codebook to code all interviews. We team-coded each interview in a 3-step process to support clarity and accuracy of codes and definitions in the codebook, application of codes to data, and ensure intercoder reliability (Miles et al., 2013). The steps were: 1) one coder fully coded an interview, 2) the second coder reviewed the coded interview to confirm code application, and 3) the two coders came together to discuss and correct any coding discrepancies and reach 100% consensus. Coders alternated their coding order, switching who coded interviews first or second, to build greater reliability between coders (Saldana, 2013).

Results

Ranchers identified livestock protection approaches and discussed three categories related to how they understood and perceived these approaches, including: 1) which approaches they are aware of and familiar with, 2) their motivations for implementing approaches, and 3) barriers they face when considering implementing approaches. Additionally, ranchers described non-predation related operational challenges, caused by environmental and sociopolitical factors, that may limit their capacity to implement approaches.

Livestock Protection Approaches Identified by Ranchers

Ranchers collectively identified 26 types of approaches (Table 2). Some producers had extensive prior experience with one or multiple approaches, while others had little to no knowledge of or experience with any. Ranchers mentioned being interested in specific approaches, such as range riding, but had not tried them yet. When sharing perceptions about how useful or effective various approaches are, ranchers discussed their belief that effectiveness is contextual, depending on livestock species, carnivore species, and/or the specific ranch. Overall, ranchers described each ranching context as unique and that tools and strategies are not equally applicable to every context. Several ranchers emphasized sheep's high predation vulnerability and that tool stacking, layering approaches spatially, temporally, or both, is an optimal way to use multiple approaches to protect livestock most effectively. For example, ranchers described successfully protecting sheep by combining a herder, livestock guardian dogs, and night penning. In contrast, cattle ranchers more frequently discussed utilizing one approach at a time or none at all. Some ranchers felt that certain approaches were effective for specific carnivores but not the species they had concerns about. For example, some ranchers believed

fladry might only be effective for wolves, not other carnivores, and therefore were not interested in the investment. Additionally, ranchers discussed their success with strategies, such as synchronizing calving season with the local wild prey birthing season, thereby reducing vulnerability to predation. Another strategy ranchers mentioned was selecting livestock grazing locations that are less appealing or less accessible to carnivores.

Table 2: Complete list of livestock protection approaches identified by ranchers.

Tools and Strategies
Aerial surveying for livestock and carnivore locations
Breed selection and selective breeding
Carcass management/attractant removal
Electric fencing
Feeding full-term pregnant cows during evening to encourage daytime calving
Fladry, turbo fladry
Grouping mixed species in shared pastures
Hazing carnivores away from livestock
Herding
Human presence
Increasing herd density
Improving herd health to reduce vulnerability
Livestock guardian animals (dogs, donkeys, llamas)
Night penning
Notifications to ranchers about carnivore locations, provided by wildlife managers
Pay for presence
Range riding
Rotational grazing
Scare tactics: visual (Foxlights), acoustic (Critter Gitters)
Seasonal calving
Selecting safer calving locations
Selecting safer livestock grazing locations
Stockmanship
Tool stacking
Virtual fence and GPS tracking
Wildlife cameras

Motivations for Implementing Approaches

Every rancher described at least one of four motivations that may increase their willingness to implement various livestock protection approaches or continue using an approach

with which they already have experience: 1) concern about carnivore predation, 2) the belief that using various approaches will lead to additional benefits beyond reducing livestock-carnivore conflict, 3) personal experiences successfully utilizing approaches in the past, and 4) stories from others who have had positive experiences using approaches (Table 3).

Table 3: Motivations and barriers to rancher adoption of livestock protection approaches, in order of number of ranchers who discussed them - highest on top, lowest on bottom.

Motivations and Barriers Described by Ranchers
Motivations
Concern about carnivore predation
Perceived non-predation related benefits (e.g., time with family, better sleep, etc.)
Positive personal experiences
Positive stories from others
Barriers
Perceived incompatibility with ranching operation
Lack of knowledge and resources
Perceived ineffectiveness of approaches
General opposition to change
Negative personal experiences
Negative stories from others
Tolerance of carnivores and predation
Perceived pressures from their ranching community

Concern About Carnivore Predation

Twenty-three ranchers discussed concerns about carnivores as a primary motivator for implementing livestock protection approaches and discussed motivation emerging from concern that carnivores are or will be present near their operations or from experiencing predation events. Ranchers mentioned several carnivore species present in their rangelands, including coyotes, black bears, mountain lions, and gray wolves. Despite a small population (fewer than 30 in Colorado when interviews were conducted), concern about wolves was a common focus, likely because interviews occurred in the midst of Colorado's gray wolf reintroduction. When ranchers discussed concerns about wolf recolonization, some expressed motivation to implement

approaches before wolves were present, while others indicated that they would be motivated to implement approaches after wolves were present or after a predation event.

In one example, a rancher described how bear presence motivated them to consider implementing night penning in addition to having a herder:

> *The bears are like bulls in a China shop; they just stumble into the middle of a herd and wreak havoc. So, they come in and the sheep scatter, and then that makes a lot of work for the herder the next day. That's why we've considered night penning.*

Another rancher described how predation events have encouraged them to use livestock protection approaches:

> *If I find a calf that the tail is short or the hind quarters are eaten, or if the calf's dead, that'll start putting me on alert, and I'll pay more attention if I see another occurrence. And it's like, okay, I need to start being proactive.*

When discussing livestock protection, one rancher talked about implementing night penning in response to a bear attack:

> *Predators are always a problem. We had a bear kill a ram and three ewes last year. That's why we bring the sheep in.*

When discussing how concern about carnivore presence is a motivator, one rancher described being proactive about adapting livestock protection for wolves early on:

> *Several years ago, whenever the whole wolf discussion started, then we started looking into that too. It's like, so what are we going to do because this is going to happen one way or the other.*

Another rancher indicated a strong interest in implementing protection approaches once they observed wolves on their operation:

*This year when the wolves first showed up, like here's tracks on our property, big eye opener. Big holy sh*t, let's pull out the A team and try to get something done to where we're not gonna be losing a lot of cattle.*

Perceived Non-Predation Related Benefits

Twenty-three ranchers discussed their belief that livestock protection approaches provide additional benefits unrelated to reducing conflict with carnivores. Ranchers described three non-predation benefits as key motivators for implementing such approaches: 1) operational benefits, such as efficient use of time and money, 2) livestock health benefits, and 3) rangeland health benefits.

One rancher described their motivation to move calving season to later spring in order to save time and money on feed and labor:

Over the last 15 years, we've been bumping calving later. Once we got into April, I started noticing significant differences... First off, we didn't have to feed the cows because they weren't about to calve in the middle of winter. And then, the calf loss, calving needs labor. You know, some cows eat the placenta for nutrient reclamation, but some of them just leave it, which attracts things because now you've got this rotting flesh mass out there… Since we started calving into the April zone, I haven't seen one, so there's less that attracts predators.

Another rancher described saving time checking their animals by using virtual fencing, a grazing management approach which helps track and contain livestock:

You spend more time looking at your cattle instead of looking for them.

One rancher described numerous benefits from one strategy, rotational grazing, including rangeland health, livestock health, and efficiency with time and money:

I just got back from moving 100 cattle into three acres, and we'll do that every day or twice a day all summer, which is how grasslands evolved… If you are properly managing from a holistic perspective, your ecosystem should be happy, which means your cattle are happy, which means you're making money which means you're able to take time off, which means you enjoy your work.

Positive Personal Experiences

Twenty-two ranchers discussed positive personal experiences with an approach as a motivation for continuing to use that approach or potentially trying others. Specifically, they expressed continued motivation after finding the approach effective at reducing predation or predation risk. Ranchers described positive experiences in three ways: 1) observing carnivores avoiding livestock after interacting with an approach, 2) observing reduced predation after implementing an approach, and 3) perceiving efficacy of an approach without directly observing reduced losses.

One rancher described seeing livestock guardian animals deter mountain lions:

I have direct evidence of mountain lions walking through the yard and choosing not to pursue the goats because the llamas were there.

Another rancher described witnessing wolves interacting with and being deterred by fladry:

This year, seeing the wolves respond to the fladry, I'm convinced 100% that it's effective with the wolves.

In another example, a rancher described livestock guardian dogs reducing predation:

I had pretty much zero predation once I got the dogs… they just naturally take to wandering and guarding, whether it's sheep or goats or geese or chickens or cattle… They worked, and I knew they worked because predation stopped. I didn't have chicken

losses. I didn't have any cattle losses. My sheep were never threatened, or the couple goats that I had.

One rancher described how increasing herd density is effective for reducing livestock vulnerability:

You know, one animal out by itself, they will take it. But if they're all in a bunch, the calves are with the mothers in these tight groups, there's almost no predation.

Positive Stories from Others

Eleven ranchers discussed that hearing others' stories about positive experiences and successes with various approaches was a motivator for implementing them. There were two main ways ranchers discussed hearing stories: 1) hearing a positive story from someone they knew personally, and 2) hearing broader success stories from a secondhand source, such as television, radio, online, books, and social media.

For example, one Colorado rancher described hearing firsthand from Montana ranchers about success from synchronizing cow calving with wild prey birthing season:

Talking to the guys in Montana, that's what they did as well, they moved their calving date to match up with the deer and the elk, and that helped a lot with their predation.

Another rancher described how their interest in llamas increased because a rancher they knew had success with llamas protecting their livestock:

I know a guy that has llamas, and he swears by it. We might get some llamas. I like that idea, because they're out there 24/7 watching stuff.

One rancher discussed their interest in trying electric fencing after hearing about success in other states:

Montana's done a lot of them… The wolves up there aren't as big an issue to a lot of them

guys. The grizzly bears are, and so they hot wire them out, and they're finding that it's keeping the wolves out too. So, the hot wire may be something we have to do…

Barriers to Implementing Approaches

Ranchers described eight barriers that would deter them from adopting or continuing to utilize an approach: 1) believing that approaches are not compatible with their specific ranching operation, 2) lacking knowledge or resources to implement approaches, 3) believing approaches are ineffective, 4) general opposition to change, 5) having negative personal experiences when utilizing approaches, 6) hearing stories from others who had negative experiences using approaches, 7) tolerating carnivores and/or predation, and 8) perceiving negative impacts on or pressures from their ranching community (Table 3).

Perceived Incompatibility with Ranching Operation

Twenty-five ranchers described their belief that approaches are not compatible with their particular ranching operation in three ways: 1) rangelands are too large scale or too remote for approaches to be feasible, 2) specific approaches conflict with other aspects of their operation, and 3) regulations prohibit approaches on public lands.

One rancher explained that guardian dogs are unable to protect livestock when they are spread out in large pastures:

When you completely turn the animals loose in a 3,000- or 4,000-acre pasture, the guard dogs become way less effective. They just can't manage that big of an area.

Another rancher described how the remote location of ranches in their area was incompatible with virtual fencing:

A couple of other ranches in the valley have tried the collars, but they're in areas where they didn't have enough internet connection with a nearest receiver, so it wasn't working.

Another rancher described how feeding guardian dogs in remote areas of their operation would create conflict with carnivores:

> *We have enough bears that as soon as you put up a feeding station with dogs, you're gonna do nothing but feed the bears, and your dogs are gonna be worn out from fighting the bears out of their dog food all day. So, we eliminated the dogs on that end of things.*

Another rancher described how loud approaches like scare devices are incompatible with other land uses at their ranch, such as hunting:

> *We graze on some of these allotments into hunting season. You can't be up there during hunting season shooting off a bunch of pop rockets with a whole bunch of people trying to sneak up on elk, you're gonna get caught in the back. So, you pretty much have to scratch that one off the list.*

One rancher discussed how public land regulations and liability make some approaches unsuitable:

> *How do you put up wolf mitigation tools on public land?... You can't fladry public land, forest land. You sure as hell don't want dogs running around on forest land. Liability is a big thing too.*

Lack of Knowledge and Resources

Twenty-four ranchers shared that lacking knowledge and resources is a barrier to implementing approaches. While some were interested in trying approaches, they described not knowing how to properly utilize them. Some ranchers also discussed lacking resources and capacity as barriers to implementing approaches, including: 1) funding to purchase or maintain tools, and 2) person-power for labor intensive approaches.

One rancher described having livestock guardian dogs but lacking knowledge about how to utilize and take care of them:

> *I don't think we're taking good enough care and we truly understand. We need some protocol for best practices for care and feeding of livestock guardian dogs.*

Another rancher described interest in a tool, Foxlights, but lacking the knowledge to use them:

> *I love the ideas about the lights, and I don't know how common or how easy it is to get set up with some of these lights. I don't know how they're operated, I mean, are they battery or do you have to have a gas generator?*

When discussing the benefits of range riding, one rancher described the cost as prohibitive:

> *I think range riding would be awesome, but I don't know a ranch around that can afford that… The cost of range riding is outrageous.*

One rancher described range riding as a useful strategy, but skilled labor was a limiting factor:

> *A range rider needs to understand the livestock, they need to understand the landscape, and they need to understand the predators. That's a very specific set of skills that I think is going to be hard to find.*

Another rancher described financial limitations forcing them to seek off-ranch employment, which meant less person-power on the ranch to protect livestock:

> *I went back to work full time. Previously, I probably spent three days a week riding and checking on the cows. I don't have that option now.*

Perceived Ineffectiveness of Approaches

Twenty-one ranchers discussed their belief that specific or all livestock protection approaches are ineffective, thus they are unlikely to use them. There were three primary ways ranchers perceived approaches to be ineffective: 1) the general belief for unstated reasons that

approaches do not work, 2) approaches only work temporarily and are therefore ineffective, and 3) approaches only work for some, not all, carnivores and are therefore ineffective.

One rancher explained that they do not think fladry is effective and did not provide a reason but did convey their lack of interest in this approach:

> *We're not interested in the fladry. I just don't think it's gonna work, in my opinion.*

Another rancher described approaches being temporary as an indication that they do not work:

> *The fladry, the Foxlights, that stuff is temporary. It doesn't work.*

Another rancher, described fladry as ineffective for deterring mountain lions:

> *Fladry and mountain lions, I've never heard of that working.*

General Opposition to Change

Seventeen ranchers discussed being generally opposed to making changes to their current management practices in three ways: 1) preferring maintaining traditions and continuing their current management practices, 2) discomfort with trying new things, and 3) resisting change for sociopolitical reasons.

When considering management changes, one rancher explained that they prefer to maintain ranching practices that have been working for their operation already:

> *The way we're doing it, the way it's always been done, we had no issues.*

Another rancher described their ranching community resisting change because they value maintaining their current practices:

> *I do things a lot differently than they do, and they believe you should do things the way their grandfather and dad did it… They have a hard time looking at new technologies to bring into their ranching, to become more profitable, more efficient. They don't have an open mind. They don't want the support. They don't like trying new things.*

One rancher objected to change caused by sociopolitical factors beyond their control:

> *The wolves are being introduced. Now we have to change our operations. Why should we have to do all that stuff just because of politics?*

Another rancher described loss of autonomy as a barrier for their community to utilize livestock protection approaches:

> *I think that opposition to this thing [wolves] being imposed on us is the number one barrier for a lot of folks.*

Negative Personal Experiences

Fifteen ranchers discussed that a negative personal experience with a livestock protection approach was a barrier to continuing to use that approach or, for some, being willing to try any other approach. Ranchers described having negative personal experiences specifically with three types of approaches: 1) livestock guardian dogs, 2) fencing, and 3) herd density.

One rancher described guardian animals getting picked up by the public:

> *Sometimes people steal our dogs from the forest. They think that there's a lost dog… and they don't realize there's a herd of sheep there too… There's a dog, and they go out and catch it and they take it into the dog shelter.*

Another rancher explained that they stopped night penning because lambs struggled with the fencing:

> *We tried night penning years ago. The issue we had was that the lambs kept tearing it down and getting their heads stuck in it.*

When discussing increasing herd density to protect calves from predation, one rancher explained that sanitation issues arise:

> *It takes us 60 days to calve cows. When you're keeping them in a tight area for 60 days,*

you end up with a heavy manure cover. Then babies are being born into the manure… These are all challenges.

Negative Stories from Others

Fifteen ranchers discussed that hearing other ranchers' stories about negative experiences or a lack of success with livestock protection approaches may decrease their willingness to try an approach themselves. Ranchers described hearing negative stories in two ways: 1) from someone they know personally, and 2) from a secondhand source, such as television, radio, online, books, and social media.

One rancher described how their neighbors' problems with fladry influenced their decision against using it:

The neighbor saw a lot of problems with it [fladry]... one being it was hard to keep up in the wind, and it really messed up the migration of the elk and the deer this spring… between the elk and the deer tearing it down and the wind and whatnot, it really wasn't a fit for me, so I did not apply for it.

Another rancher described how they heard a secondhand story that deterred them from removing carcass piles and managing carcasses:

I heard this the other day - I don't know whether it's fact or fiction - he had wolves, he had a bone pile, he put carcasses there. [A wildlife manager] asked him to remove it, and once he removed the bone pile, that's when his predation started. Now, I don't know if that's true or not… Once you remove the source of food, then what happens with the live animals?

Tolerance of Carnivores and Predation

Six ranchers described tolerating a certain level of carnivore presence and losses to predation because it is an expected part of ranching and/or they believe that there is nothing they can do about it.

For example, one rancher explained that they do not worry about predation because it is beyond their control in some locations, so they accept their losses and are not interested in implementing protection approaches:

> *I wouldn't say that I worry about [predation], because there's really nothing I can do about it. Where [cows] hang out down in the canyons, I'm not there all the time. I know I lose. I figure there's like a 10% loss of calves every year that go to bears and mountain lions down in canyons in the wintertime.*

Perceived Pressures from Their Ranching Community

Five ranchers discussed concerns about negatively impacting their neighbors and ranching community as well as peer influence as a barrier to implementing approaches. They described these community concerns as a barrier in two ways: 1) concern about pushing carnivores from their own ranches into their neighbors' ranches, and 2) lack of social acceptance of livestock protection approaches by others in their community.

One rancher described challenges created by implementing approaches successfully on their ranch potentially causing problems for a neighbor:

> *With all the hazing tools, it's kind of bittersweet because we are a tight community, we're kind of like a giant family around here… When you haze [a carnivore] off of you, you're sending it to your neighbor because we're all right here together.*

Another rancher explained that their community was unlikely to utilize fladry because the aesthetic that fladry created ran counter to the social norm for their landscape:

> *I don't think fladry is gonna fly here. If the wolves come, maybe some people will try it. But… people are very particular about what they're looking at when they drive around and hike around, and people are going to be upset if there's red plastic flags flying around.*

Operational Challenges

Additionally, ranchers collectively described fifteen non-predation related challenges their ranching operations face that pose risks to livestock welfare and income. These challenges presented management hurdles that required time, effort, and resources. With limited resources, ranchers may have to choose between management objectives, such as protecting livestock from predation and providing drinking water to livestock. While ranchers may want to use various livestock protection approaches, navigating other pressing management issues can limit their capacity to do so. Ranchers described two key types of challenges that limit their capacity to engage with new approaches: 1) environmental factors, and 2) sociopolitical pressures (Table 4).

Table 4: Complete list of operational challenges identified by ranchers, in order of number of ranchers who discussed them - highest on top, lowest on bottom.

Environmental and Sociopolitical Challenges Described by Ranchers
Environmental Challenges
Water/drought
Winter weather
Disease
Poisonous and unpalatable plants
Non-carnivore wildlife
Wildfire
Sociopolitical Challenges
Market fluctuations and high operating costs
Public perceptions of ranching
Development of subdivisions
Neighborhood relationships
Recreation
Water access and rights
Lack of transparent communication from agencies and wildlife managers
People stealing or shooting livestock
Skilled labor limitations

Ranchers described six types of environmental factors: 1) water/drought, 2) winter weather, 3) disease, 4) poisonous and unpalatable plants, 5) non-carnivore wildlife, and 6) wildfire.

For example, one rancher described weather as a year-round concern:

> *Weather is a 365 days a year concern, and so one of your biggest challenges is to try to work around the weather, whether it's drought in the summertime or big time storms and getting your cattle fed in the wintertime.*

Another rancher described harsh winter impacts on their rancher partner:

> *He lost 20% of his herd because of the weather and the calves being born and literally freezing to the ground. It was horrible. It was so cold and muddy.*

A rancher described how drought and resulting wildlife can diminish livestock forage:

> *When it gets dry, the pests come out. We have a biblical grasshopper plague. They ate everything, and then the prairie dogs came out and instead of having a couple hundred*

now you have a couple hundred million. It's the snowball effect of not having adequate forage, and you can't recover because there's stuff out there that wants to eat it.

Another rancher explained how elk present a challenge to crops and income:

In terms of loss of income, the elk are the biggest problem… What we would like to get compensation for is the loss of crops due to elk.

Ranchers also spoke about nine different sociopolitical pressures: 1) market fluctuations and high operating costs, 2) public perceptions of ranching, 3) development of subdivisions, 4) neighborhood relationships, 5) recreation, 6) water access and rights, 7) lack of transparent communication from agencies and wildlife managers, 8) people stealing or shooting livestock, and 9) skilled labor limitations.

One rancher described increased subdivisions presenting challenges with gates and fencing in their neighborhood:

You know, every once in a while, somebody will go along and open the gate and let my cows out. That kind of sucks.

Another rancher described subdivisions changing the local culture and negatively impacting their ranching operation:

Our little valley used to be all ranches. Now we have 4 big subdivisions… They automatically think that means they have water when they don't have water rights. They don't like driving cattle on the road because the manure gets on their vehicles. We can't even take our dogs, because they won't slow down. It's been really challenging to run cattle here with all the subdivisions.

Another rancher discussed how increased recreation presents challenges by scattering livestock, making it difficult to collect and protect animals at night:

The biggest [challenge] is disruption to our herding, like a bike race or motorcycles… Sometimes somebody comes in and splits up our herd, then I can't keep track of the herd. Dogs can't do their best job with animal control, and maybe all the sheep don't get in the group at night, and those are ones that are going to be dead the next morning.

Discussion

This study explored ranchers' perspectives about and experiences with livestock protection approaches that reduce predation risk, including which tools and strategies ranchers are familiar with, factors motivating them to utilize approaches, barriers they face for implementing approaches, and broader operational challenges. To do so, we applied McKenzie-Mohr's community-based social marketing framework with the aim of informing potential management interventions (McKenzie-Mohr, 2011). Ranchers described several factors that influence their willingness and ability to adopt livestock protection approaches, such as their own experiences, others' experiences, perceived social norms, predation concerns, and resource needs. Additionally, ranchers discussed a plethora of non-predation challenges they face, such as drought and neighborhood development, which limit their capacity to address livestock predation issues. Ultimately, our study contributes to a small, but growing, body of investigations on what drives rancher behavior regarding carnivore-related livestock management decisions (Willcox et al., 2012) by identifying patterns in ranchers' perspectives that practitioners can harness to remove barriers and leverage motivations to reduce carnivore-livestock conflicts.

Several motivations and barriers that ranchers identified mirrored each other, allowing practitioners to potentially address paired motivations and barriers simultaneously. For example, ranchers described previous personal success with livestock protection approaches, or hearing

about another rancher's successes, as a powerful motivator for future or continued implementation of approaches. Conversely, ranchers discussed that their own or others' negative experiences with approaches made them wary or unwilling to implement any type of approach in the future. For example, one rancher described a prior attempt to attach a deterrent that flashed bright lights and made loud noises to a sheep's body. This failed by frightening the sheep, which then ran back to the flock, frightening other sheep and scattering the flock, ultimately increasing sheep vulnerability and work for the rancher. This negative experience caused the rancher to lose interest in using any livestock protection approaches more broadly.

This finding reflects research that suggests perceived self-efficacy, an individual's belief they can succeed in achieving a goal, shapes their decision-making (Bandura, 1982; Bruyere et al., 2022), making these early experiences disproportionately impactful in shaping future intentions to engage in certain behaviors, such as utilizing livestock protection approaches. One such study on farmer engagement with conservation agriculture found that farmers who experienced success with environmentally-friendly farming practices, such as reducing chemical and water use, were more likely to continue utilizing them, and farmers wanted to see others experiencing success with new practices before adopting the practices themselves (Perry & Davenport, 2020). This suggests that those seeking to mitigate livestock-carnivore conflict should be intentional about setting up approaches for success early on, strongly avoiding failures, and leverage individual ranchers' positive experiences to encourage other ranchers to utilize approaches. One way to promote success is to assess site suitability ahead of implementing approaches to make sure the proposed approaches are appropriate for each unique context. Moreover, while experimentation is essential for innovation, it must be done cautiously to avoid damaging the broader momentum for adopting approaches. When testing an approach with a less

predictable outcome, it may be best implemented in a low-stakes area, where conflict is lower or buy-in is already high, to avoid negative experiences in a sensitive community.

We also found that social pressure influences ranchers' willingness to employ approaches, including social norms, i.e., the perceived typical or expected behaviors within their networks. People tend to behave in ways that they expect others will also behave, as well as in ways they believe influential others expect of them (Rimal & Real, 2005). For example, ranchers described social pressure as a concern about their reputation and the risk of being ostracized by their community, particularly when considering highly visible tools such as fladry. Some ranchers shared concerns that their neighbors may feel betrayed if they participated in cost-share programs or received support from agencies or organizations to help protect their livestock from carnivores. Perceptions of social norms are highly impactful and guide personal opinions and behaviors (Tankard & Paluck, 2016; Willcox et al., 2012). Previous research found that negative opinions from community members drives ranchers away from utilizing innovative management strategies, such as rotational grazing or rangeland monitoring (Didier & Brunson, 2004). Gonzalez et al. (2024) found that social norms influenced how people planned to vote on wolf restoration in Colorado. Specifically, when participants perceived that the majority of others planned to vote a certain way or expected them to vote a certain way, they were more likely to also plan to vote that way. Similarly, other research identified social norms as the most influential predictor of rancher engagement in wildlife-friendly management practices, indicating that the perceived support of family, friends, and community members significantly increased their likelihood of utilizing these practices (Willcox et al., 2012).

Harnessing Diffusion of Innovation Theory is one potential avenue for addressing community-based barriers to adopting livestock protection strategies. This theory describes how

new behaviors diffuse through a community, starting with innovators and early adopters, gradually gathering momentum over time. Communication and observable behaviors in peers is key (Rogers, 1983). In addition, other research suggests that opinion leaders (i.e., influential individuals within a social network) can be used to accelerate diffusion of new behaviors in a community (Valente & Davis, 1999). By sharing early successes with livestock protection approaches, these leaders can act as change agents (Valente & Pumpuang, 2007), shifting perceptions of socially acceptable ranching practices and encouraging uptake of new management approaches. One effective strategy to leverage opinion leaders may be through existing community meetings, where trust is already established, to foster collaboration amongst neighbors around shared conservation concerns (Wilson et al., 2017; Niemiec et al., 2019). These gatherings provide opportunities to build mutual understanding, reinforce shared values, and build on prior collective action to effect community-level change.

McKenzie-Mohr and Schultz (2014) note that diffusion of new behaviors is particularly effective when behaviors are visible, such as with physical tools (e.g., fladry, flashing lights, or fencing). However, our findings show that ranchers are concerned about demonstrating visible tools, so this approach needs to be addressed strategically, carefully selecting for opinion leaders to take initial actions in contexts where the visible tools are highly likely to be effective. Moreover, the Theory of Planned behavior suggests that people behave in ways they believe that others expect them to and ways that they feel capable (Ajzen, 1991; Hagger et al., 2020). Therefore, a multifaceted intervention might include supporting opinion leaders' early success, using community meetings to leverage social ties, promoting visible tools that neighbors can easily observe and understand, and empowering ranchers to feel capable of implementing new approaches. Research supports this combined approach. For example, when opinion leaders

visibly adopt new practices, they not only legitimize these behaviors but also create opportunities for peer-to-peer learning, which can boost community participation and maintain long-term engagement (Bakti et al., 2024). Given the power of peer influence (Skaalsveen et al., 2020; Tran-Nam & Tiet, 2022), practitioners should consider amplifying the successes of influential ranchers to encourage widespread adoption of livestock protection approaches.

We found that some Colorado ranchers were motivated to integrate approaches into ranch management for non-predation related objectives, and they reported experiencing reduced predation as a secondary benefit. Additionally, many operational challenges that ranchers identified can be addressed by strategies that double as nonlethal livestock protection approaches (Barnes, 2015). For example, one rancher described how they shifted calving dates from mid-winter to late spring to minimize winter calf losses and labor inputs. The later calving dates meant grass was available at peak nutrition while mother cows were lactating, eliminating the need for and cost of supplemental feed, and placentas remained unfrozen for dams to eat after giving birth. An additional unintended benefit was that it eliminated calf losses to predation. Another rancher described implementing intensive rotational grazing practices to promote healthy forage, avoid disease and poisonous plants, and manage water availability, and they also found that the human presence required for intensive rotational grazing eliminated predation. This finding reflects prior research which identified that keeping livestock in dense herds that frequently move across a landscape (i.e., practices associated with rotational grazing, virtual fencing, herding, and range riding), synchronizing calving with wild prey birthing season (Barnes, 2015), low stress stockmanship (Grandin, 2020), and selective breeding for defensive traits (Stear et al., 2001) achieve management benefits related to improved livestock handling and income security while also ensuring that livestock is less vulnerable to predation (Barnes,

2015; Barnes & Howell, 2013). Several ranchers also discussed that predation and other operational challenges caused diminished mental health and lack of sleep. Ranching is a high stress occupation, underscoring the continual need for interventions that support the mental health and wellbeing of ranchers (Chengane et al., 2021; Rudolphi et al., 2020). All of the above approaches can contribute to the wellbeing of both ranchers and livestock by holistically improving ranch operations, in addition to reducing predation. Simultaneously addressing ranchers' broader management objectives and livestock predation vulnerability could promote livestock and rangeland health, sustainable ranching livelihoods, rancher mental health, and carnivore conservation. Promoting approaches that address this array of objectives may further encourage adoption of such approaches.

Our findings highlight that predation threat resides in a much larger context of ranchers' operational challenges. Ranchers cited numerous non-predation challenges that threaten their operations and limit their capacity to learn and implement approaches. For example, many ranchers shared that because they must work off-ranch jobs to provide supplemental income, they have limited capacity to monitor their livestock, install physical tools, or employ labor-intensive management strategies, leaving livestock vulnerable to predation threats. These complex challenges impact ranching operations and rancher livelihoods and demand a systems approach. A systems approach to conservation agriculture jointly addresses multiple management objectives in unison (e.g., soil and water conservation, nutrient retention, soil quality improvement, and efficient energy use), resulting in cumulative successes, such as intensified sustainable production, improved livelihood, and climate resilience (Lal, 2015). Prior work also suggests that managing grazing as a system, with practices including rotational grazing, low-stress livestock handling, herd density, and calving on green grass, offers benefits

such as quality forage production, plant biodiversity, increased organic matter, and improved livestock health, while simultaneously reducing predation risk (Barnes, 2015; Bradley & Pletscher, 2005; Franzluebbers et al., 2012). This holistic approach to ranch management, incorporating practices that stack functions, could improve ranchers' capacity to implement approaches that address multiple management objectives, improving production and resilience, reducing predation, and protecting carnivores. Given our findings that non-predation related objectives, such as improving livestock and rangeland health, motivate ranchers to implement approaches, practitioners might promote approaches through interventions that ensure multiple management benefits to offer more efficient support for livestock health, rangeland health, and ranching income, while concurrently minimizing predation risk.

We found that ranchers in our sample are not frequently utilizing livestock protection approaches despite being familiar with a wide array of options available to them. More work is needed to close the divide between awareness of approaches and on-the-ground implementation. Across all interviews, ranchers mentioned 26 unique approaches at least once, indicating cursory awareness of available approaches, though not necessarily fluency or frequency of implementation. In fact, 24 ranchers discussed lacking knowledge and resources (e.g., money, time, skills, and materials) as a barrier to utilizing approaches. In Colorado, state agencies, academic institutions, and nonprofits offer technical and financial support to local producers for livestock protection, and increasingly with the wolf restoration effort beginning in 2023. Many ranchers in our study indicated that they also need help selecting, acquiring, and installing these approaches, demonstrating the necessity of connecting ranchers with the individuals, organizations, and agencies offering exactly this type of support. Given our findings on social influence, interventions such as peer-to-peer learning or knowledge exchanges amongst ranchers

may be particularly effective for overcoming both resistance and lack of knowledge (Boronyak et al., 2022) through delivering culturally-relevant information and resources about which livestock protection options work in various ranching contexts and how to find and properly utilize them. Other work has also shown that ranchers trust each other and have varied levels of trust in agencies and nonprofits (Bogezi et al., 2021; Smith et al., 2025). Utilizing each ranching community's trust in other ranchers for learning and sharing information may enhance willingness to adopt these approaches (Boronyak et al., 2022; Rodela, 2011).

Limitations

We did not ask for demographic information on ethnicity, so we cannot accurately measure these demographics for our study participants. While the demographics of ranchers we interviewed likely reflect the predominant demographics of ranchers in Colorado (Colorado State Demography Office, 2023), our interviews missed important perspectives from more varied demographics, which could have provided more depth and diverse views about the approaches, motivations, and barriers represented. We contacted several organizations and individuals in an effort to include Black, Indigenous, and People of Color (BIPOC), particularly Indigenous, ranchers in our study but were unsuccessful in those efforts given the short time span of our study. Engagement with Tribal Nations requires trust and relationship building over a longer time frame, something our research team plans to do for future efforts. The original human inhabitants of Colorado are Native tribes including Apache, Arapaho, Cheyenne, Pueblo, Shoshone, and Ute Nations (Snody, 2020), and Native people of these Tribes are important voices in carnivore-livestock conflict and coexistence issues in Colorado. Lack of BIPOC study participants limits diversity of perspectives and excludes people who rightfully should be included in any North American research regarding land uses, natural resources, and wildlife

management. For future research, we suggest contacting leaders of Tribal Nations early in project development and including Tribes in research design from the beginning.

Conclusion

Our study contributes to the body of literature elucidating what is needed to encourage rancher adoption of approaches, though more research is needed about why ranchers do or do not employ specific tools or strategies. We offer novel findings about ranchers' motivations and barriers when considering adopting livestock protection approaches to mitigate predation risk. Future research should harness our application of the community-based social marketing framework to design a strategy with tailored behavior change interventions, according to our identified motivations and barriers (McKenzie-Mohr & Schultz, 2014). In particular, we illustrate the strong influence of peers and social networks when ranchers are considering utilizing new approaches. One way practitioners could leverage the influence of social norms would be to work with opinion leaders to advocate for livestock protection approaches. Another avenue could be to work with early adopters to demonstrate success with visible approaches (e.g., fladry, fencing, and livestock guardian dogs). We suggest focusing on pathways for peer influence to combat negative community opinions and, instead, effect management changes by combining behavior change interventions such as community meetings, opinion leaders, and visible tools. Many of these interventions, such as engaging ranchers at community meetings, are already being utilized by state agencies, nonprofits, and conservation practitioners, thus there is momentum to build on in some contexts.

While our research focused on carnivore-related ranching issues, we found that an array of operational and financial challenges limit ranchers' capacity to learn and implement new approaches, and predation threats can be exacerbated in the context of these other challenges. We

therefore suggest that practitioners apply a systems approach to mitigating broader ranching challenges that simultaneously addresses reducing predation risk, rather than isolating predation from other concerns. Future research could contribute to an informed systems approach by identifying the highest priority threats to ranching livelihoods so that we may truly understand how much of a threat actual predation is (United States Department of Agriculture, 2015) and holistically support ranching operations.

The wildlife conservation potential on rangelands is significant, particularly as carnivore populations are decreasing and habitat is shrinking (Ripple et al., 2014), and research suggests that carnivore conservation in rangelands should focus on incorporating wildlife-friendly management practices into regular ranch operations (Willcox et al., 2012). Practitioners can use our findings to work with ranchers in culturally relevant ways that meet their needs and address multiple management objectives at once. We broadly identified Colorado ranchers' familiarity with approaches, motivations, and barriers, thus future research might explore which approaches ranchers are most interested in utilizing and which motivations and barriers are most prevalent. Understanding these perceptions is essential to the collaborative process of supporting both ranching and healthy wildlife populations.

While this study is Colorado-based, these results can be applied broadly beyond Colorado because carnivore-livestock interactions are a global concern. While ranchers around the world inevitably have different challenges and varying perspectives, the risks associated with carnivore predation are universal. The approaches recognized by ranchers in this study should be considered for livestock protection globally, and many have been implemented in various contexts for generations (van Eeden, Eklund, et al., 2018). Our study and application of community-based social marketing can serve as a model for future work to find pathways for

mitigating carnivore-livestock conflicts in diverse social-ecological systems worldwide. This study underscores the importance of understanding and listening to rancher perspectives as an onramp to conflict mitigation solutions. We, as researchers, call upon conservation practitioners and ranchers alike to deeply listen to each other's perspectives and collaborate on finding solutions which collectively protect ranching livelihoods, livestock, and wild carnivores.

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Appendix A

Project Summary

Colorado rancher perspectives on livestock protection tools

Principal investigator: Veronica Yovovich, PhD, CSU Extension

Project summary:

Carnivore populations have been recovering and reclaiming recently unoccupied habitat, with a corresponding increase in the intensity and frequency of livestock predation and other negative impacts. While there are many potential tools and strategies available to livestock producers and land managers, there is little research on what tools ranchers are already using, how to best reach ranchers in Colorado, and what influences these tools and practices have on other aspects of ranching operations. This project involves interviewing livestock producers across Colorado to learn more about what local ranchers think about livestock protection options and how we can best tailor Extension activities to suit their needs. This will allow us to better understand the range of viable management strategies for addressing local challenges that Colorado ranchers face when avoiding carnivore predation on livestock. We are looking for rancher partners from across the state to interview and learn more about their operations. Our ultimate goal is to use this information to inform Extension programs and support Colorado's ranching community.

Objectives:

1. Interviewing Colorado ranchers to gather information on current practices they use to protect their livestock against carnivore predation; to understand their perspectives on what types of protection tools producers deem feasible for Colorado, regardless of

previous experience with those tools; and to understand the other concerns and challenges Colorado producers face that Extension can work on

2. Creating outreach materials from our findings to share with ranchers and Extension
3. Building relationships for future livestock protection research and extension programming

What we're looking for in collaborating producers:

- Cattle or sheep operations of any size or type anywhere in Colorado
- Prior conflicts with carnivores are not necessary to participate and grazing operations could have any type of carnivores present, or none at all
- Willingness to participate in a roughly 60-minute interview with project staff (CSU Extension and graduate students) and to share experiences and perspectives to enhance our understanding of this issue from those in Colorado's working lands

What we bring to the collaboration:

- Access to livestock protection expertise and resources
- A desire to create and tailor Extension programs to meet the specific needs of Colorado ranchers
- We aim to strengthen the bridges between ranchers, Extension, and local researchers, and we are keen to hear of other ways in which our work can support Colorado's rangeland communities

Our contact info is: Veronica Yovovich - V.Yovovich@colostate.edu, (970) 491-5924

Mireille Gonzalez - Mireille.Gonzalez@colostate.edu

Jenna Brager - Jenna.Brager@colostate.edu

Please reach out if you have questions or might be interested in being involved -

We are very happy to discuss the project in greater detail!

Thank you for considering working with us!

Appendix B

Consent

Colorado State University

Consent to Participate in Research

Impacts of grazing management practices on rangeland ecology and management

Introduction and Purpose

My name is Jenna Brager. I am a graduate student at Colorado State University working with my faculty advisor, Dr. Veronica Yovovich, in the Warner College of Natural Resources. I would like to invite you to take part in my research study, which looks at grazing management in Colorado.

Procedures

If you agree to participate in my research, I will conduct an interview with you at a time and location of your choice. The interview will involve questions about your experience with and perspective on livestock management practices. It should last about 30 to 60 minutes. With your permission, I will audiotape and take notes during the interview. The recording is to accurately record the information you provide and will be used for transcription purposes only. If you choose not to be audiotaped, I will take notes instead. If you agree to being audiotaped but feel uncomfortable or change your mind for any reason during the interview, I can turn off the recorder at your request. Or if you do not wish to continue, you can stop the interview at any time. I expect to conduct only one interview; however, I may wish to follow-up with you for added clarification. If so, I will contact you by email/phone to request additional information.

Benefits

There is no direct benefit to you from taking part in this study. I hope that the research will provide useful information to help CSU Extension design research and programing to help support you and other Colorado ranchers.

Risks/Discomforts

We do not anticipate that any of the research will pose any risk or discomfort, however, you are free to decline to answer any questions you do not wish to, or to stop the interview at any time. As with all research, there is a chance that confidentiality could be compromised; however, we are taking precautions to minimize this risk.

Confidentiality

Your study data will be handled as confidentially as possible. If results of this study are published or presented, individual names and other personally identifiable information will not be used if you elect for us to do so. To minimize the risks to confidentiality, we will keep all our notes and recordings in a secure server in which only myself and my collaborators will have access. We will transcribe the audio recordings as soon as possible after the interview and then destroy the tapes. When the research is completed, I will save the transcriptions and other study data for possible use in future research done by myself or others. Identifiers may be removed from your interview information, and this anonymized data could be used for future research studies without additional informed consent from the subject. The same measures described above will be taken to protect confidentiality of this study data. We may be asked to share the research files with the sponsor or the CSU Institutional Review Board ethics committee for auditing purposes.

Compensation

You will not be paid for taking part in this study.

Rights

Participation in research is completely voluntary. You are free to decline to take part in the project. You can decline to answer any questions and are free to stop taking part in the project at any time. Whether or not you choose to participate in the research and whether or not you choose to answer any questions or continue participating in the project, there will be no penalty to you or loss of benefits to which you are otherwise entitled.

Questions

If you have any questions about this research, please feel free to contact me at Jenna.Brager@colostate.edu;

or project PI, Veronica Yovovich at (970) 491-5924 or v.yovovich@colostate.edu;

or project collaborator Mireille Gonzalez at Mireille.Gonzalez@colostate.edu.

If you have any questions about your rights or treatment as a research participant in this study, please contact the Colorado State University Institutional Review Board (IRB) at: 970-491-1553, or e-mail CSU_IRB@colostate.edu .

CONSENT

Participant Consent:

Your signature acknowledges that you have read the information stated and voluntarily wish to participate in this research. Your signature also acknowledges that you have received, on the date signed, a copy of this document.

_____ _____

Signature of participant Date

_____

Name of participant *(please print)*

Do you consent for your interview to be audiotaped?

___Yes

___No

If you agree to allow your name or other identifying information to be included in all final reports, publications, and/or presentations resulting from this research, please sign and date below.

_____ _____

Participant's Signature Date

Appendix C

Interview Guide

Thank you so much for meeting with me today, I am really looking forward to learning from you! Before we begin, I'd like to give you a bit of context for this study. The overall project is about evaluating impacts of various livestock protection tools on livestock and rangeland health. This portion of the project that you are participating in now involves interviewing livestock producers across Colorado to learn more about ranching operations and what local ranchers think about livestock protection options. This will allow us to better understand the range of viable management strategies for addressing the challenges that Colorado ranchers face when avoiding carnivore predation on livestock. Our ultimate goal is to use this information to inform Extension programs and support Colorado's ranching community.

Do you have any questions about the project?

Before we get started, I just have a little bit of housekeeping to cover.

First, I know we sent along some information about this study, but I just wanted to reiterate a few things. So, for this study, we are really interested in learning about your rangeland management practices and your perspectives on various livestock protection practices. This interview will take around an hour to complete, but if you need to end early just let me know and if you end up having more you want to share once we reach the hour, I am happy to stay on! Finally, your participation in this interview is completely voluntary so you can choose to stop participating at any time, you won't hurt my feelings! You can also email me later if you decide you do not want me to use part of, or any of, this interview. We will keep all of your responses confidential and only members of the research team will see your responses, and when we write

results from our study, your responses will be kept completely anonymous. Lastly, I would like to record this interview, if that is ok with you, so that I can make sure I am staying engaged in this conversation with you and so that I can re-read/listen to your responses in more depth later.

I am done monologuing now!! Do you have any questions? Is it ok if I start recording?

…

Wonderful!! I am going to start pretty broadly here, and I am wondering if you can tell me…

…

Priming questions:

- Can you tell me a little bit about you and your operation? Your experience and history with ranching in Colorado?
    - Potential follow ups (these are somewhere to start, and all are not all necessary)
        - What kind of operation do you have (cow-calf or stockers)?
        - Do you graze mostly on private or public land?
            - What kind of public land? (forest service, BLM, state…)
        - What counties do you work in?
        - How long have you (or your family) been ranching?
        - What breed of cattle do you run?
        - How did you get into ranching?
        - Is ranching your primary occupation?
        - What do you like most about being a rancher?
        - Do you run cattle anywhere outside of Colorado?

Background questions:

- Can you generally describe what your grazing management practices look like?

- Potential probing/follow up questions
    - How spread out are your cattle on average day/night? (How long does it take you to travel between grazing areas? What percentage of your animals do you see on a given day/night?)
    - Do you ever have people out with your herd at night?

Concerns/Challenges:

- If you think about the last 2-3 years of running your operation, what were your biggest on the ground challenges?
- If you think about the next 2-3 years, what are you most concerned about?
- How would you rank carnivore predation among the various challenges that you encounter in your ranching operation?
    - What in particular do you worry about?
    - Is this something you worry about on a typical day? (How often is this a concern for you?)
    - Which carnivores do you have?
- Have you ever had animals killed or injured by carnivores? If so, how do you respond?
    - How often do you find a dead animal (livestock)?
    - How do you determine if the death was caused by a carnivore?
    - What do you do with livestock carcasses on your property?

Barriers & Motivations for using Preventative Tools:

The main goal for this interview is to learn more specifically about practices and tools you may or may not use or know about for protecting your livestock from carnivores, things like range

riding, fladry, fencing, FoxLights, seasonal calving or calving near home sites, carcass removal, shepherding, and so on.

- Are you familiar with any of these tools? (Which ones are you most familiar with?) Do you currently use or have you used any of these practices/tools to avoid livestock incidents and losses?
    - **If they say yes, they have used:**
        - Can you describe your experience using this approach/tools?
            - Potential probing:
            - Which ones? How long did you use them? Can you describe how you used them?
            - Do you think it was effective? Why/why not?
            - Do you plan to continue in the future?
            - How/why did you decide to try them?
            - [If yes, but have stopped] Why did you stop using those tools/strategies?
            - Would you recommend using them to others?
    - **If they say no, they have not used:**
        - Are there tools you have considered using? Why did you decide not to use them?
        - Is this something you could be interested in the future?
            - **[if no]**
                - What is it about these tools/approaches that you find unappealing?

- Do you think they serve any potential benefit?

- **[if yes]**
  - What approaches do you envision yourself using, why?
  - Are there specific circumstances where you could see yourself using these tools?
  - What has prevented you from using them?
  - If you had the resources you needed, how might you engage differently with these livestock protection tools?

Learning, Support, & Broader Questions:

- Do you think any of these practices/tools influence or could influence other aspects of your operation (either positively or negatively)? If so, what/how?
  - For example, do livestock protection tools influence how your cattle move around grazing areas?
- Where did you learn about livestock protection tools? Where would you go to learn more about these and other tools?
- Do you know other ranchers using or talking about using these tools? What do you see your neighbors doing to protect their livestock? Do you see them using any particular tools?
- Do you think other ranchers might be interested in using them? Why/why not?
- More generally, what kind of support do you think would be helpful to you and other Colorado ranchers?
- Is there anything else you would like to share or that you think I should have asked?

Appendix D

Codebook

Category 1: Concerns, Challenges, Predation Rank, and Support

Definition: This category includes all themes and codes related to participants' descriptions of the concerns and challenges they face in their operations, where these concerns and challenges rank compared to risk of carnivore predation, and the kinds of support they would find helpful. Concerns include issues that could pose a risk to their livestock welfare and income. Concerns are generally spoken about as future possibilities. Challenges include management hurdles that require time, effort, and resources to overcome and mitigate. Challenges apply more to past and present. Challenges impact ability to care for and manage livestock and rangeland in what participants deem to be optimal ways, ability to generate sufficient and stable income, and social discord. Predation rank is when participants discuss where carnivore predation or threat of predation ranks amongst the various other concerns and challenges identified here. Support means resources and efforts that ranchers have talked about benefiting their operation, which could be offered by agencies, organizations, and other external sources, (e.g., education, changes in public perceptions).

Subcategory: Concerns and Challenges

Definition: When describing the key concerns and challenges they face, ranchers most often described two key types of pressures that could negatively impact their operation: (1) environmental factors and (2) social and political pressures. Environmental factors included such things as winter weather, rainfall and drought, poisonous and unpalatable plants, and various wildlife. Social and political pressures included development, public perceptions of ranching,

neighborhood discord, and lack of transparency in communication, that pose challenges to ranching operations and grazing management. All of these concerns in various combinations can result in mental health impacts on ranchers.

Theme: Environmental and wildlife

- **Non-carnivore wildlife**: this code is for when participants describe livestock and operational interactions with non-carnivore wildlife, largely including deer and elk, ungulates eating hay and competing for forage, and negative interactions with fencing.
- **Winter weather**: this code is for when participants talk about cold temperatures, deep snow, and winter storms resulting in calf losses due to freezing. It also includes discussion of increased labor, stress, and management challenges due to winter weather.
- **Disease**: this code is for when participants discuss livestock losses due to disease, contagion in close quarters, vulnerability to disease by calving in bunches near the home site.
- **Poisonous and unpalatable plants**: this code is for when participants discuss livestock losses due to eating poisonous plants, i.e. larkspur, operational challenges like avoidance of pastures at certain times of year, and reduced amount of available forage due to undesirable and/or unpalatable plants taking up pasture space.
- **Water/Drought** (liberal): this code is for when participants describe a variety of issues with water in an environmental context. Drought is prevalent and one of many concerns. In addition to drought, interviewees discuss resulting declines in forage, the need to use pastures differently, and competition with wildlife. Exclude: water issues pertaining to the sociopolitical challenges in the sociopolitical section.

- **Wildfire**: this code is for when participants discuss the threat of wildfire to their livestock, rangeland, income, or any aspect of their operation, including past impacts and future concerns.
- **Carnivores** (conservative): this code is specifically for when participants discuss concerns and challenges with carnivores present in their landscapes, actual predation, threat of predation, frequency of concern about predation (including seasonally, i.e., during calving season), management responses to predation and predation threats/carnivore presence. Carnivores mentioned include bears, mountain lions, coyotes, wolves, domestic feral dogs, and raptors. This code is for past, present, and future concerns about carnivores, including indirect effects like stress, reduced weaning weights, increased vigilance, changed foraging behaviors, and various financial losses, etc. Exclude: Level of losses and predation rank - these inherently involve carnivores, no need to be redundant. This code does not include discussion of specific livestock protection approaches and tools in regard to reducing predation threat by carnivores. It also excludes when carnivores are talked about as not being a concern or a threat.
- **Carnivores - not a concern** (conservative)**:** this code is for when participants refer to carnivores as not being a concern, whether they have predation events or not. For example, a rancher could have zero history of predation and therefore not be concerned, or a rancher could have losses to predation and also not be concerned.

Theme: Sociopolitical

- Development pressures - direct and indirect: this code is for when participants describe both indirect and direct pressures as a result of development in their neighborhoods and communities. The definitions of these pressures include the following subcodes:

- **Subdivisions and neighbor relations** (liberal)
    - Result in conflict with dogs, both ranch dogs and neighbors' dogs
    - Cultural shifts in neighborhoods, resulting in negative perceptions of ranching practices as well as diminishing access to ranching supplies and operational support. Exclude: broader meaning of negative public perception and ignorance that happens beyond the neighborhood.
    - Fencing disputes regarding livestock wandering off home ranches
    - Exclude: positive mentions of neighbors and neighborhood relationships
- **Water access and rights** (liberal)
    - Water access, rights and allocations, communication with water providers and managers, management, and misunderstandings with neighbors.
    - Exclude: environmental water issues in the environmental concerns section.
- **Recreation**
    - Changes in land use for recreational purposes, i.e. hiking and mountain biking, increased human population utilizing open spaces nearby ranches. This results in changes to cattle and wildlife movements, creating conflict in hay field use, vulnerability to predation, and vulnerability to negative human perceptions of ranching and operational strategies.

- **Lack of transparent communication** (conservative)
    - Related to agency and wildlife managers' communication with ranchers about wildlife management, i.e. locations of carnivores, wolves with GPS collars. Exclude: communication challenges related to water.

- **Negative public perceptions and ignorance** (liberal)
    - This pertains to ranchers' loss of autonomy and ability to make their own management decisions due to the larger/big picture public not considering the impacts wildlife management decisions have on ranching, the impacts of certain ballot initiatives on ranching, i.e. wolf reintroduction, upcoming mountain lion hunting, lamb slaughterhouse in Denver.
- **Human threats to livestock**
    - Theft of livestock, killing/shooting of livestock, and using livestock as bait
- **Finances/Economics** (conservative)
    - This pertains to when ranchers talk about the high cost of inputs, cattle market fluctuations, and the high cost of skilled labor. This also includes when ranchers discuss needing off-ranch jobs to generate enough income to support the ranch and ranching lifestyle. Exclude: livestock losses included in the challenges category, money and resources (i.e. skilled labor) in the Barriers category, relating specifically to barriers to the use of nonlethal tools.
- **Labor** (conservative)
    - This is about availability of labor/help/hired staff. Sometimes participants talk about limited availability of any labor, and sometimes they talk about limited availability of skilled labor. This code includes both. Exclude: cost of labor (found in finances/economics), barriers to using tools being lack of labor/resources.

Subcategory: Predation Rank (liberal)

Definition: This is when participants talk about where carnivore predation ranks amongst the various other challenges they face in their operation. Some say it ranks high and is a daily concern, some say it is not a concern at all, others are somewhere on that spectrum.

*For this subcategory, we will chunk code to see how we can assess this information.

Exclude: level of losses in specific numbers or percentages.

Subcategory: Support

Theme:

- **Rancher education about ranching**
    - Definition: when ranchers discuss learning more about ranching practices, from each other, from workshops, from organizations. This also addresses the need for education to be accessible. Exclude: nonlethal livestock protection approaches.
- **Education for others about ranching**
    - Definition: Education for CPW, the public, the urban population. The goal of this type of education is to make ranching better understood and explain the stewardship benefits of ranching. This education addresses the need to educate the public on the positive value of ranching and works to dissolve stigmas, building connections and relationships between the public and ranching communities.
- **Resources to support implementation of nonlethal tools** (conservative)
    - Definition: access to nonlethals (where to get them, how to bring them to my ranch), knowledge of how to use and implement them, knowledge about context (operation, livestock, where and how are they appropriate and feasible), bolster capacity to implement nonlethals with additional labor and skill sets. Exclude:

when participants discuss lack of knowledge and resources in the context of that being a barrier to using nonlethals.

- **Agency support for managing carnivores** (conservative)
    - Definition: this support comes from agency staff taking actions or collaborating with ranchers for joint actions. This support includes addressing chronic depredation, permission to use lethal, and streamlining the compensation process and taking the burden of proof off the rancher.
    - Ranchers described agency support to mean transparent communication, improved methods of reaching people, and bridging the technology gap.
- **Water support** (liberal)
    - Definition: This code is specifically for water as it relates to support that ranchers are seeking, including education for others about water access and rights so that ranchers' water rights are clearly understood (especially amongst neighbors), herd health as related to water access, water transportation - movement of water to where and when it is needed, better communication with water managers and timing of water allocation, influence on rotational grazing - support for better grazing practices by having the needed water supply at the right times, having sufficient quantity of water for operational needs (livestock, irrigation). Exclude: water issues in the concerns and challenges section, related to environmental and sociopolitical concerns about water.

Category 2: Motivations - Tools

Definition: This category includes all the motivations that ranchers mentioned when considering the use of nonlethal livestock protection approaches, what would make them inclined to consider

using a tool, implement a tool, or continue using a tool they already have experience with. This includes participants themselves as well as their perceptions of what would motivate other ranchers in Colorado.

Themes:

- **Successful personal experience** (conservative)**:** this includes when a rancher has used a tool and has found it to be effective at reducing predation or mitigating the threat of predation on livestock.
- **Firsthand positive stories** (conservative)**:** this includes when a participant discusses hearing a positive or successful story about the use of a livestock protection tool from a personal contact, someone they are talking with directly has firsthand experience.
- **Secondhand positive stories** (liberal)**:** this includes when a participant discusses hearing a positive or successful story about the use of a livestock protection tool from a secondary source, referring to broader rancher success (excluding personal contacts), other states, tv, radio, online, books, social media.
- **Concern about wolf presence/predation** (conservative)
    - Proactive: this includes when participants discuss being aware that wolves will be coming to their area and they are motivated to learn about nonlethals and start implementing them before wolves are present and before the threat of wolf predation
    - Reactive: this includes when participants discuss that they will not be motivated to learn about or implement nonlethals until wolves are actively posing a risk to their livestock or after a predation event by wolves
- **Threat/presence of non-wolf carnivores**

- **Actual predation events** (conservative)**:** this includes when ranchers discuss motivation to learn about and try nonlethals in response to a predation event by any carnivore, either on their own property or nearby on a neighbor's property.
- **Perceived other benefits and incentives** (liberal): these positive impacts come from the use of nonlethal tools but result in non-carnivore related benefits to ranching operations, livestock health, and rangeland health, i.e. range riding helps with animal health, protects riparian areas, finding fences that need fixing, etc.
    - This includes when ranchers discuss multiple benefits of implementing nonlethals, whether the main motivation is reducing predation or the main motivation is livestock health and good husbandry. This can go in both directions. Commonly human presence is a tool which is referred to as having many benefits, carnivore management being among them. Seasonal calving has a market-driven motivation and can also be a nonlethal tool. Vence is a grazing management tool that also can function as a nonlethal approach to carnivore management. Rotational grazing helps with rangeland health and vegetation management as well as functioning as a nonlethal tool by increasing human presence. Wildlife cameras, in addition to being a nonlethal tool, can alert a rancher to an injured or sick cow/sheep in need of attention.
    - Other incentives include efficient use of time and money, allowing for reduced workload and more time with family.

<u>Category 3: Barriers - Tools</u>

Definition: This category includes the barriers that ranchers said would prevent or discourage them from considering the use of nonlethal livestock protection approaches, what would make

them opposed to using a tool, implementing a tool, or discontinue the use of a tool they already have experience with. This includes participants themselves as well as their perceptions of what would be a barrier for other ranchers in Colorado.

Themes:

- **Money, resources** (liberal)**:** tools are too expensive, not cost effective. Lack of labor, lack of skills and skilled labor. Limited capacity for everyone on the ranch, too busy. Busy working off ranch to make enough income to support the ranch, not enough time to implement tools.
- **Perceived ineffectiveness - unstated** (conservative)**:** just because, unstated reason.
- **Perceived ineffectiveness - temporary** (conservative)**:** temporary effectiveness is perceived as not being effective enough (i.e. fladry), without any firsthand experience.
- **Perceived ineffectiveness - specific carnivore** (conservative): This is sometimes specific to wolves or another carnivore - tools are perceived as possibly effective for some carnivores but definitely not effective for others.
- **Firsthand negative stories** (conservative)**:** This is when a rancher has a firsthand personal connection with a neighbor or other rancher they are close with who directly told the interviewee about an experience with a nonlethal not working.
- **Secondhand negative stories** (liberal)**:** This is when a rancher has heard a secondhand story from news, media, a friend of a friend, etc. about a tool not working.
- **Peer pressure/other people's negative perception of me:** this is when participants discuss neighborhood pressures, like maintaining a certain reputation, that discourage the use of nonlethals. This also includes when ranchers are concerned about the use of nonlethals resulting in pushing carnivores onto neighboring ranches, thereby causing

predation issues for their neighbors and community. I.e. fladry will upset my neighbors and cause them to criticize me, or participating in programs with support for nonlethals is "selling out." This includes ugliness or aesthetics, i.e. when ranchers are concerned that fladry will cause their property to look like a "used car lot."

- **Opposition to change** (conservative)**:** this is when participants discuss maintaining traditions, continuing the practices they've been using for a long time, maintaining the management that they learned from their parents and grandparents, not wanting to try new things, not wanting to work toward tolerance for carnivores, having wolves forced on them and therefore being unwilling to try tools to live with wolves. This includes participants talking about themselves as well as speaking about other ranchers and the ranching community more broadly.
- **Lack of knowledge of tools, finding them, using them:** this is when participants discuss that they are not familiar with nonlethals, they don't know what they are, where to find them, how to use them, how to acquire them. This can include when ranchers are willing to try them but don't know how. Exclude: when ranchers are talking about wanting support to use nonlethals.
- **Bad personal experience** (conservative)**:** this includes when ranchers have tried a tool and had a negative experience or an actual experience of the tool being ineffective, i.e. elk and deer getting tangled in fladry, using Foxlights and having a predation event anyway. This includes experiences of tool-induced stress on livestock (i.e. range riding stress on cows, cattle being afraid and reactive to LGDs), LGDs being dog-napped, LGDs interfering with herding dogs, LGDs causing damage to wildlife.

- **Incompatible with my property/operation/species:** it isn't compatible, i.e. my terrain is too large or too rough for range riding to be feasible, my operation is too small to invest in these tools, my cattle are too spread out to find them for calving, I have too many cows to bunch because they will get disease, this will degrade my rangeland/soil/vegetation, etc.
- **Tolerance** (conservative): Perspectives include "nothing you can do", "comes with the territory", "to be expected". Acceptance of a certain level of losses to predation without feeling the need to take action.

Category 4: Level of losses due to predation (liberal)

Definition: this is when a participant specifically mentions losses due to predation, over any amount of time. This includes the interviewee's losses as well as losses they have heard about from others.

***Chunk code, export to see if meaningful

Category 5: Learning Sources

Definition: this is specific to nonlethal tools and is for when participants talk about where they would go or have gone to learn about nonlethal tools, sources and pathways for gathering information and resources about nonlethals.

- **Peer to peer**, rancher to rancher, neighbor to neighbor, states living with wolves: this is when participants discuss learning from other ranching practitioners, people that they know and live near as well as people in other states who are already living with wolves.
- **Social media channels**: this is when participants have mentioned learning about nonlethals and other resources via social media channels that share information about

ranch management and where carnivores are present, particularly mountain lions and wolves

- **Influential individuals**: thought leaders, teachers, and well known practitioners
- **Classes, workshops, events** (i.e. auction barn, county fair, livestock sales, etc.)
- **Books**
- **Internet**
- **newspaper, media**
- **podcasts** (from universities)
- **Government Agencies:** CPW, USDA, CSU
- **Extension**
- **NRCS, local conservation districts**
- **Producer Organizations** (Cattlemens, Stockgrowers, Woolgrowers)
- **WLA, Working Circle**

Category 6: Interest in Tools/Strategies

Definition: this is when participants express a willingness to learn about or implement nonlethal livestock protection approaches that they have not yet tried, are not currently using, or are using but would be interested in increasing. This can refer to general interest/willingness or refer to specific tools.

*Use the list of specific tools here as much as possible to link them to interest!

Category 7: Lack of Interest in Tools/Strategies

Definition: this is when participants express general lack of interest in nonlethals or refer to lack of interest in regard to a specific tool. This may link closely with barriers - it's important to

differentiate lack of interest from barriers, though there may be some overlap, i.e. “fladry won’t work for my operation so I am not interested in it.”

*Use the list of specific tools here as much as possible to link them to lack of interest!

Category 8: List of Nonlethal Tools

Definition: livestock protection approaches (physical tools, practices, strategies) that are designed to effectively reduce the threat of carnivore predation on livestock. *We are aiming to avoid coding for specific tools on their own. We are coding to associate tools with: 1. Motivations, 2. Barriers, 3. Interest in a tool, 4. Lack of interest in a tool. Ideally, all tools should have co-occurrence with one of these four categories.

- Fladry, turbo fladry
- Electric fencing
- Night penning
- Range riding
- Human presence (exclude range riding and herding)
- Herding
- Scare tactics - Visual, including Fox lights, lights in corral, and others
- Scare tactics - Noisemaking, including cracker shells, gun shots, cannons, and others
- Scare tactics - Motion detector, including Critter Gitters
- Livestock guardian animals: dogs, donkeys, llamas
- Wildlife cameras
- Carcass management/attractant removal (includes using lime powder on carcasses)
- Seasonal calving - to synchronize with wild prey calving, to mitigate winter weather, can help add human presence

- Calving location, near home site
- Breed selection and selective breeding: this includes selecting breeds of livestock that are known to have more defensive behavior, bunching behavior, night penning behavior. It also includes breeding individual animals that have demonstrated specific desirable behaviors that make them less predation and/or compatibility with good stockmanship.
- Bunching mixed species of livestock to protect smaller species
- Notification of carnivore locations
- Livestock location (near home site, etc.)
- Herd density (cattle grouping)
- Virtual fence and GPS tracking collars
- Rotational grazing, moving livestock frequently
- Herd health reducing vulnerability
- Stockmanship, low stress livestock handling
- Aerial survey (drones, planes)
- Pay for presence
- Nighttime feeding for daytime calving - feeding cattle at night/dark, the food works in their stomach, therefore they'll calve mostly during daylight hours (6am-8pm).
- Hazing - rubber bullets
- Tool stacking - using multiple tools together, temporally or spatially stacked